PB-250 552

RESTRICTING DUST EMISSION FROM FORCED-DRAFT BOILER INSTALLATIONS, CAPACITY 30-600 TON/HR AND OVER, HARD COAL-DUST FIRED WITH LIQUID ASH REMOVAL

Public Health Service

Prepared for:

Environmental Protection Agency

November 1961

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

BIBLIOGRAPHIC DATA SHEET	1. Report No. APTD-1585	2.	3. Recipient's Accession No. PB250552
4. Title and Subtitle Restricting Dust Emission from Forced-Draft Boiler Installations Capacity 30-600 Ton/Hr and Over, Hard Coal-Dust Fired with Liquid Ash Removal			5. Report Date November, 1961 6.
7. Author(s)			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Verein Deutscher Ingenieure Kommission Reinhaltung der Luft German;			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address U.S. Department of Health, Education, and Welfare Public Health Service Washington, D.C.			13. Type of Report & Period Covered 14.

15. Supplementary Notes
Translation of VDI-Richtlinien 2093

16. Abstracts
The purposes of these specifications are: to describe parts of the installation in which dust occurs; to characterize the influences leading to the formation of dust; to point out measures for the selection of suitable dust-removal installations and their maintenance; and to establish guide lines for the restriction of dust emission by new installations.

17. Key Words and Document Analysis. 17a. Descriptors
Air pollution
Air pollution control equipment
Boilers
Combustion gases
Dust
Coal

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

PRICES SUBJECT TO CHANGE

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 30
	20. Security Class (This Page) UNCLASSIFIED	22. Price $4.00-2.25

079024

PB 250 552

VDI-RICHTLINIEN

November 1961

VEREIN DEUTSCHER INGENIEURE	Staubauswurfbegrenzung Dampferzeuger uber 10 t/h Leistung Steinkohlen-Staubfeuerungen mit flussigem Ascheabzug	VDI 2093

APTD-1585

RESTRICTING DUST EMISSION FROM FORCED-DRAFT BOILER INSTALLATIONS, CAPACITY 30-600 TON/HR AND OVER, HARD COAL-DUST FIRED WITH LIQUID ASH REMOVAL

This publication, translated from the German, was prepared by the Association of Steam Boiler Owners, Essen, in collaboration with the Technical Inspection Services, Essen. All rights reserved.

Reproduced with permission by the
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Washington, D. C.

VDI-Kommission Reinhaltung der Luft

VDI-Handbuch Reinhaltung der Luft

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

Foreword

This is one of several dozen VDI Clean Air Committee specifications on air purification which the Division of Air Pollution of the U.S. Public Health Service has obtained permission to translate, publish, and distribute in limited quantity. A complete list of the VDI publications being published by the Division of Air Pollution appears on the inside back cover. Because the VDI Committee from time to time revises these specifications, this and other publications in the series may be superseded by later publications.

The VDI Clean Air Committee specifications are compiled by trade or professional associations and published by the Committee. The Committee has neither official status nor regulatory authority, although West German governmental agencies participate in its activities. Air quality specifications published by the Committee are therefore advisory, rather than regulatory. They may however later be adopted by West German governmental authorities.

The English translations were done by the Joint Publications Research Service of the Office of Technical Services, U.S. Department of Commerce. It should be borne in mind that various terms literally taken from the German do not have the same connotation in English; for example, the word "standard" frequently appears where the word "criteria" might better reflect the comparable American meaning, since in this country "standard" is generally meant to imply a legally enforceable value, while "criteria" usually means a recommended value upon which standards may be based.

The publication and distribution of these translations by the Public Health Service constitutes neither endorsement of the specifications nor of the air quality or emission limitations recommended in them. We believe that they contain much useful information that would otherwise not be available to non-readers of German and for this reason have made them available to workers in the air pollution field in the United States.

RESTRICTING DUST EMISSION FROM FORCED-DRAFT BOILER INSTALLATIONS, CAPACITY 30-600 TON/HR AND OVER, HARD COAL-DUST FIRED WITH LIQUID ASH REMOVAL

Prepared by:

Association of Steam Boiler Owners, Essen
in collaboration with
Technical Inspection Services, Essen.

VDI No. 2093, November 1961

TABLE OF CONTENTS

		Page
	VDI Committee for Air Purification	iii
	Introduction	1
1.	Technology	2
	Guide Values for Standard Furnace Installations	2
2.	Reduction of Dust Emission	4
2.1	Influences within Steam Generators	4
2.2	Dust Precipitation in Dust Removal Installations	7
2.21	Efficiency Rates	10
2.22	Influence on Efficiency Rate of Separators	12
2.221	Mechanical Dust Separators	12
2.222	Electrostatic Precipitators	13
2.3	Stacks	14
3.	Restriction of Dust Emission	15
3.1	Restriction of Emission on the Basis of Deposition	15
3.2	Restriction of Emission on the Basis of Technical Factors	15
3.21	Instructions for Utilization of Diagram	16
	References	21

VDI COMMITTEE FOR AIR PURIFICATION

The VDI Committee for Air Purification is composed of experts in all fields of importance for air purification. These experts collaborate with the Committee on their own responsibility and without compensation and are proposed for the Committee by the following societies and institutions:

German Society for Hygiene and Microbiology
German Society for Oil and Coal Chemistry
German Society of Gas and Water Experts
German Meteorological Services
Society of German Chemists
Society of German Iron Mine and Steel Mill Experts
Association of Anthracite Mines
Technical Inspection Associations
Society of German Steel Mill Experts
Society of German Foundry Experts
VDI Trade Section on Dust Technology
Association of Steam Boiler Owners

Scientists from Universities and Institutes in Biology, Chemistry, Forestry and Agriculture, Human and Veterinary Medicine, Metallurgy, Physics, and Technology
Research Institute of the Cement Industry

Federation of German Industry (Chemical Industry, Oil Industry, Automobile Industry, etc.)
German Federal Railroads
Federation of German Farmers
Federation of Community Associations
Settlement Federation of the Ruhr-Coal District
Competent Federal and State Ministries
Institute for Water, Soil, and Air Hygiene of the Federal Public Health Service
Public Inspection Services

INTRODUCTION

The VDI Specifications on Air Purification are divided into the following groups:

1. Permissible Immission Concentration (PIC-values)
2. Calculation of the Distribution of Dust and Gas
3. Restriction of the Emission of Dust and Gas
4. Dust and Gas Measuring Techniques.

In the evaluation of problems of air pollution, the inner relation of these four groups of specifications must be considered.

The present specifications concern the occurrence and reduction of dust emission in steam generating installations with a capacity of 30-600 ton/hr and over.

It is the purpose of the specifications:

/ > to describe parts of the installation in which dust occurs,

to characterize the influences leading to the formation of dust;

to point out measures for the selection of suitable dust-removal installations and their maintenance;

to establish guide lines for the restriction of dust emission by new installations.

The measures recommended in the specifications take into account the most recent technical findings. As the latter are further developed, the specifications will be adapted to them.

VDI Specifications No. 2299 (in preparation) are applicable to the restriction of the emission of gas, including sulphur dioxide, by steam-generating installations.

1. Technology

Guide Values for Standard Furnace Installations:

In any furnace installation, dust is created which consists of fly-ash and cinders (incombustibles). The grain size of the dust can be very fine when firing coal dust and especially in smelting furnaces (more than 70% less than 10 μ). In all types of furnace firing, a part of the ash introduced into the furnace or in the boiler flues is precipitated as clinker and/or dust and in smelting furnaces with the melt.

It is an important advantage of furnaces with wet-ash removal that a large share of the combustion residues is not carried off as fine-grained fly-ash but is deposited as a coarse-grained fused mass in the combustion chamber. In order to achieve this, generally the entire fly-ash precipitated in the dust separator is returned to the fusion chamber for fusion (fly-ash recirculation).

The size of the dust-removal installation and/or the efficiency rate to be selected is influenced by the rate of ash fusion in the furnace and in the boiler flues (2).

With suitable design and proper operation of the furnace installation, black smoke (soot) should not occur (Cf. VDI Specifications No. 2300 on Restricting Emission of Dust from Steam Generators, Capacity 10 ton/hr and less; in preparation).

The following indicates average values but individual steam generators have been built for capacities and conditions which differ essentially from the data below.

Table 1

Utilization of hard coal-dust with liquid ash removal	Steam generators, capacity 30-600 ton/hr and over
Fuel range	Lean coal to caking gas coal incl. all types of coal as well as medium classification and slurry.
Grain classification	0-30 mm
Volatile components (related to water-and-ash-free coal).	8-40%
Ash content (related to water-free coal; 2, 3)	Up to 50%, generally 5-20% (high values for gas-rich coal).
Sulphur content	1-1.5%, 4 medium classification and slurry 2-3%.
Water content	5-30%, generally 5-10%
Calorific value	7,500-3,200 kcal/kg
Combustion chamber load (4).	600,000-3,000,000 kcal/m^3/hr, depending on construction, increasing from fusion funnel to cyclone.
Secondary air (4)	70-90% of combustion air, depending on fuel and furnace design; pressure 250-800 mm water and over.
Preheating of air (4).	350-450° C, depending on coal and grind.
Flue gases at smoke box	
Temperature	130-200° C
CO_2 - content	15-17%
Specific smoke volume (average value: 5)	At calorific values of 7,500; 5,000; 3,200; respectively 10.2; 7.4; 5.4 Nm^3/kg of coal.
Dust content in raw gas (related to moist gas)	Up to 70 g/Nm^3 and over depending on ash content of fuel, rate of fusion (Cf. Fig. 2), recirculated dust, incombustibles in fly-ash and method of operation.

(continued)

(continuation)

Utilization of hard coal-dust with liquid ash removal	Steam generators, capacity 30-600 ton/hr and over
Grain sizes in raw gas	Depending on type of fuel, grind, type of furnace, operation of furnace with or without fly-ash recirculation (Cf. Fig. 1).
SO_2-content in raw gas	Cf. VDI Specification No. 2299 (in preparation).
Rate of ash fusion	40-65%, in exceptional cases up to 80%.

2. Reduction of Dust Emission

2.1 Influences within Steam Generators

Table 2

In regard to formation of fly-ash, the conditions listed below act:

Point of Origin	Increasing	Reducing
Coal, Fig. 3 & 4, ①	High ash content, low content of volatile components	Low ash content, ash characteristics favorable for precipitation
Grind Fig. 3 & 4 ②	Grind too coarse (formation of cinders); grind too fine (increased share of fly-ash, unfavorable for precipitation).	Grind adapter to given type of fuel

(continued)

(continuation)

Point of Origin	Increasing	Reducing
	In combined grinding and drying with intermediate storage: discharge of vapors or conveying air a)- directly into the atmosphere or into the stack without passing through separator; b)- into the combustion chamber beyond the combustion zone; c)- of larger dust amounts into the primary flue-gas dust separator (interference with optimum precipitation through introduction of dust not suitable for separator; for this reason, (b) may also be unfavorable).	In combined grinding and drying with intermediate storage: discharge of vapors or conveying air a)- only through special electrostatic precipitators or non-combustible cloth filters when directly into the atmosphere or into the stack; b)- or by combustion with other fuel dust (if the moisture content of the vapors permits this).
Burner and combustion Fig. 3 & 4 ③	Disintegration of dust and conveying air in supply lines and burners.	Uniform, easily adjustable distribution of fuel to individual burners.
	Unfavorable position of burner and flame in combustion chamber.	Favorable position of burner and jet direction of dust flame.
	Inadequate air supply, relative velocity between fuel dust and air stream too low.	Correct air volume and good turbulence of dust at all load stages.
	Inadequate preheating of combustion air; incorrect air admission during variation of load. Poor ash fusion characteristics, inadequate ash fusion.	Velocity of secondary air not less than twice as high than that of primary air. High air temperature, complete combustion of all solid and gaseous fuel components.

(continued)

(continuation)

Point of Origin	Increasing	Reducing
	Inadequate combustion control; formation of cinders.	Highly effective combustion regulation and control.
	Fly-ash recirculation increases raw-gas dust content and load on separators; unfavorable admission and velocity of fly-ash recirculation.	High rate of ash fusion.
Combustion and radiation chambers Fig. 3 & 4 ③ and ④	Inadequate dimensions of combustion and/or radiation chamber; unfavorable relation of flame and/or smoke volume to radiation heating surfaces (poor combustion through incorrect temperature at given flame position; flame cools too quickly, clinker deposits, formation of cinders). Unfavorable flame position and direction in relation to ash pit and ash fusion melt. Inappropriate position and design of ash pit.	Correct design of combustion and/or radiation chamber. Favorable closure of fusion and combustion chamber (control of optimum fusion temperature). Correct design and heat load of combustion chamber for optimum ash fusion under partial and overloads as well as for changes of fuel characteristics.
	Unfavorable air-flow design of combustion and/or radiation chamber.	Correct air-flow design of necessary restrictions in combustion and/or radiation chamber.
	Inadequate temperature and combustion air factors in ash fusion pit under partial load.	Furnace operation with optimum combustion, prevention of unnecessary high combustion temperatures, especially with cyclone blowers (restriction of ultrafine dust formation). Maintenance of most favorable air excess.

(continued)

(continuation)

Point of Origin	Increasing	Reducing
Secondary heating surfaces and fly-ash collector Figs. 3 & 4 ⑤	Unfavorable flow factors, inadequate fly-ash collectors, admission of extraneous air when discharging dust (this may entrain already precipitated dust), failure to empty fly-ash collectors at the proper time.	Precipitation of dust through baffles, bends, and changes of cross-section; large fly-ash collectors with strongly sloping sliding surfaces; effective closure of dust-discharge traps.
	Dust clouds due to activation of soot-blower and ball-rain installations	Activation of soot-blower and ball-rain at low load when possible.
Dust separation Figs. 3 & 4 ⑥	Cf. Sec. 2.21, 2.221, 2.222.	

2.2 Dust Precipitation in Dust Removal Installations:

For the precipitation of dust from flue gases of steam generator installations, in general only centrifugal (cyclone) separators or electrostatic precipitators are suitable.

High efficiency rates can be attained with cyclones only for coarse dust. For dust with a high share of grains below 10 μ (about 50% smaller than 10 μ), electrostatic precipitators are better. However, the latter are more sensitive to overload on the gas side and to dust with particularly high electrical resistance.

Under the present status of dust techniques, it should also be possible to attain guaranteed performances, except in rare cases, when planning carefully. The measurement tolerances inherent in the measurement method utilized should be taken into account. Knowledge of the following data is important for the selectior of the type of separator:

a) Design and capacity of the steam generator and furnace installation, installation with or without fly-ash recirculation, rate of ash fusion;

b) Characteristics of fuel (volatile components, ash content, ash characteristics);

c) Amount, grain classification and characteristics of raw-gas dust;

d) Available space for separator (6);

e) Stack height and discharge conditions (gas temperature and velocity);

f) Permissible emission.

Points a, b, c influence the raw-gas volume and dust content; point f depends among others on conditions in the vicinity, orographic and meteorological factors, prior loads and on point e (Cf. Sec. 3).

The design of the separator and/or the efficiency rate of the latter is not exclusively decisive for the rate of emission. In one and the same dust separator and/or at the same efficiency rate, emission from the stack will reach higher values when the raw-gas dust content increases. In large installations and with a high ash content, it may therefore become difficult to reduce emission from the stack, through selection of a high-grade separator, to the desired degree whereas at a low raw-gas dust content, adequately low emission may already be achieved by utilization of a simple dust separator. The raw-gas dust content is especially influenced by the data listed under a and b. For the selection of the type of separators, the points a, b, c are therefore particularly important.

Measurement of dust content in raw and purified gas should be carried out according to VDI Specifications No. 2066 (7, 8) and suitable measurement distances and instruments taps should be provided already in the design of the installation together with early agreement on the measurement of amount and analysis of dust (blast sorting, sedimentation analysis, etc.) (14).

In order to prevent later discussion, it is recommended to settle already during the planning of new installations all questions important for dust removal from flue gases between the future operators, suppliers and inspection services. This includes, in addition to an unmistakable wording of the agreement on the guaranteed rate of dust precipitation, also a clear understanding of the prerequisites on which the guaranty is based. The agreed guaranty must be metrologically demonstrable in each case (14).

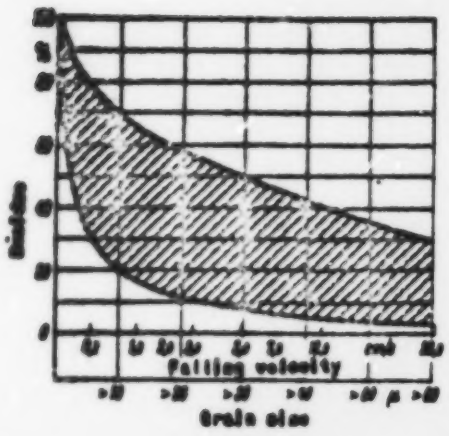
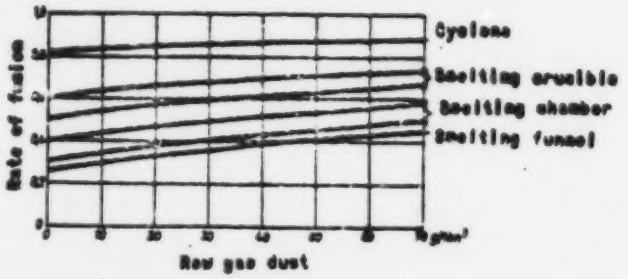


Figure 1. Classification Range of Raw-Gas Dust from Anthracite-Dust Fired Furnaces with Wet Ash Removal (from investigations of TUV Essen; 1).

(Primary measurements are the falling velocities in air from which the grain sizes so calculated are valid only for spherical particles of the specific unit weights $\gamma = 2$ g/cm^3).

Figure 2. Degree of Fusion of Different Types of Smelting Furnaces (2).



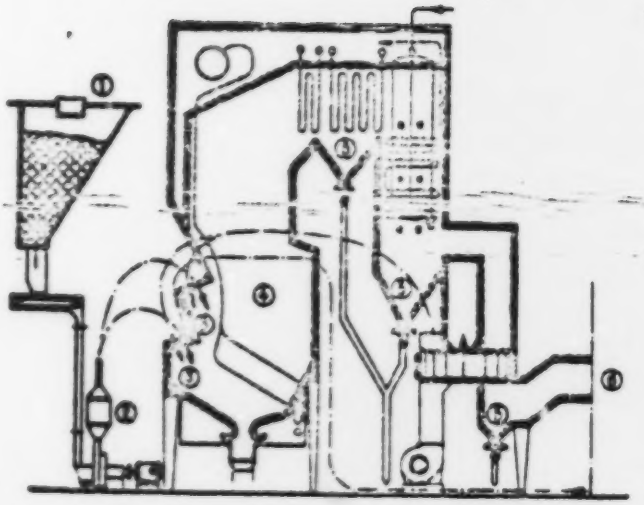


Figure 3. Diagram of Steam Generator with Anthracite-Dust Furnace and Wet Ash Removal. Numbers designate points influencing formation of dust.

1 - coal;
2 - grind;
3 - burner and combustion chamber;
4 - radiation chamber;
5 - secondary heating surfaces and dust collector;
6 - dust-removal installation.

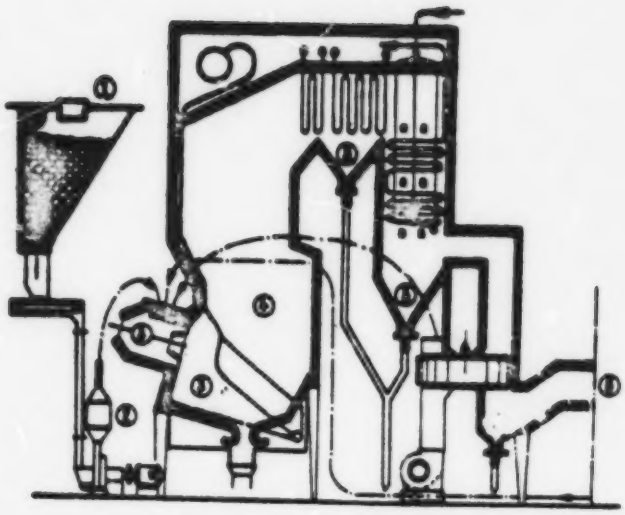


Figure 4. Diagram of Steam Generator with Cyclone Furnace. Numbers designate points influencing formation of dust.

1 - coal;
2 - grind;
3 - burner and combustion in cyclone and combustion chamber;
4 - radiation chamber;
5 - secondary heating surfaces and dust collector;
6 - dust-removal installation.

The instructions of the supplier of the dust-removal installation must be observed. The separator must be properly controlled and maintained in operation (Cf. pointers in Section 2.22 and the "Specifications on Placing Orders for Dust Removal Installations" of the Association of Steam Boiler Owners in Essen; 14).

2.21 Efficiency Rates:

The Table 3 contains efficiency rates obtained, under the present status of technology, from acceptance-inspection measurement of new installations.

In view of the inevitable drop in efficiency rate which experience shows to occur under operational conditions even with proper maintenance, the values listed in Table 3 can be valid only for the conditions on which the performance guaranty of a new installation is customarily based (absence of dirt, wear, etc.). The values of the table are therefore not applicable for the evaluation of dust emission in continuous operation (Cf. Sec. 3). The drop of the efficiency rate in operation as contrasted to the performance guaranty depends on structural and especially operational factors. It should be evaluated with great care during the planning of new installations in order to provide for an adequate interval of time between overhauls of the flue-gas purification installation in operation.

Table 3

Guaranteed Efficiency Rates of New Separators

The following values were obtained under favorable conditions, e.g., during inspection acceptance. The high values listed in the table will therefore not be attained in all cases. In special cases, installations have been constructed in which these values have been exceeded.

Type of Separator	Efficiency Rate* %	Draft required mm H_2O	Range of Utilization
Centrifugal (multi-cyclones).	Up to 90	50-100	Special case; for dust with low share of grains smaller than 10 μ.
Electro-static	Up to 98.5	5-15	Normal case.
Combined centrifugal and electro-static.	Up to 98.5	65-100	In special cases with particularly high raw-gas dust content, wide difference in classification and high share of cinders.

* Depends largely on type of dust, content of dust, fineness of dust, shape of grain, gas and operational factors. The efficiency rate alone does not give any indication on the prevention of emission.

2.22 Influence on Efficiency Rate of Separators:

2.221 Mechanical Dust Separators:

Table 4

For operational efficiency, conditions listed below are:	
Unfavorable	Favorable
High share of fine grains in raw-gas dust (Cf. Fig. 1).	Design of separator adapted to given dust classification and characteristics.
Non-uniform loading of several parallel cyclones.	Uniform distribution of flue gases to several parallel aggregates and proper air-flow design of raw-gas ducts.
Inadequate adjustability of separator.	Shut-down of one or more units under partial load.
When adjustable, incorrect adjustment of load.	
Internal leakage due to wear, bypasses between individual cyclone or separator cells.	Proper maintenance and frequent inspection of parts subject to wear and suitable lining when necessary.
Clogging of cells and dust discharge traps of individual cyclone and separator cells. Leaking valves and traps, especially of dust-discharge devices.	Prevention of temperature drop below dew point. Continuous control of measurable operating data of separators, e.g., pressure drop and energy consumption (changes in values generally indicate defects and errors).
Wrong dimensions of separator (efficiency rate depends on flue-gas throughput).	Correct dimensions of separator for normal steam-generator load.

2.222 Electrostatic Precipitators:

Table 5

For operational efficiency, conditions listed below are:	
Unfavorable	Favorable
Operational deviations from design data of separator, e.g., raw-gas volume and velocity (extraneous air, overloading), temperature, moisture, dust content, grain classification, and characteristics of dust.	Low gas velocity and adequate interval of passage through separator. Strict compliance with operating instruction.
Electrical resistance of dust too high or too low due to changes in fuel, ash or grinding, especially poor or especially good combustion, flue-gas too dry, unfavorable temperature and moisture. (Especially good combustion can result in excessive combustion chamber temperature, ash vaporization, high share of ultrafine particles and solid dust deposition on electrodes).	Favorable content of incombustibles (5-15%). Electrical resistance of dust around 10^4 and 10^{11} Ohm x cm, moist flue gas (humidifying of flue gas when necessary).
Inappropriate voltage for given characteristics of raw gas and/or dust (frequent sparking, short circuits or switch-opening). Unsuitable deposition and spray electrodes.	Maximum possible voltage through full-automatic regulation. Circuit of flue-gas flow most favorable for given type of dust and corresponding phasing of electrode voltage in the individual chambers (preionization when necessary). Adequately designed high-voltage aggregates.
Non-uniform gas and dust flow, aerodynamically unfavorable structural members in dust chamber (deposition of dust on girders, etc.). Non-uniform distribution of dust in flue-gas flow.	Uniform velocity and distribution of dust over the entire cross-section of electrofilter using baffles or perforated plates for improvement of flow when necessary. Prevention of dust accumulation in stagnant angles at baffles and electrodes.

(continued)

(continuation)

For operational efficiency, conditions listed below are:	
Unfavorable	Favorable
Inappropriate vibration (e.g. simultaneous vibration of all plates, vibration intervals too long or too short), fouled deposition electrodes (inactivation of electrical field and occurrence of clogging of entire ducts).	Proper operation and maintenance of filter-cleaning devices (vibrators, beater devices, etc.) and careful inspection of electrodes, cleaning interior of separator during boiler shutdown, when necessary.
Non-uniform or inappropriate ash removal, admission of extraneous air during ash removal, leaking ash traps. Turbulence above already deposited dust.	Regular and/or automatic ash removal; well sealed ash discharge devices and proper inspection and maintenance of the latter; prevention of admission of extraneous air (e.g. leaking valves of bypass ducts).
Poor inspection and maintenance of overall installation. Non-uniform distances of electrodes. Damage to insulators.	Systematic supervision of main units and scheduled overhaul, continuous control of measurable operating data (changes in values generally indicate defects and errors).

2.3 Stacks:

Determination of the necessary stack height and discharge cross section should be made by utilizing:

the indications in Sec. 3, Restriction of Dust Emission;
VDI Specifications No. 2299 (in preparation), Restriction of Sulphur-Dioxide Emission;
VDI Specifications No. 2289 (in preparation), Determination of Minimum Stack Height.

In addition to creating draft, an essential purpose of the stack is to discharge gas and dust as high as possible above the surface of the ground and to reduce the concentration of substances foreign-to-air

above the ground and the deposition of dust on the ground by the resulting dilution of the gases with atmospheric air (9, 10, 11, 12).

This can be accomplished by:

high stacks;
utilization of the thermic lift of the smoke streamer;
high discharge velocity of flue gas at the top of the stack.

At the same temperature and velocity of flue gas, greater thermic lift may be expected from one stack (with larger diameter) than by distributing the same volume of flue gas over several stacks of smaller diameter. For this reason, the discharge of the flue gases from several steam generators by one chimney with a large diameter may be more advantageous than several stacks with correspondingly smaller diameters. Any decision in regard to this must, however, take into account partial load factors.

3. Restriction of Dust Emission

All newly constructed steam-generating installations fired with ash-containing fuels must be equipped with dust-removal installations which should be designed -- unless Sec. 3.1 makes higher demands -- according to the conditions for restriction of emission in Sec. 3.2 and in the diagram "Restriction of Dust Emission in Newly Constructed Installations". All such dust-removal installations must correspond to the most recent technical findings (15, 16).

3.1 Restriction of Emission on the Basis of Deposition:

The emission of dust from an installation should be restricted on the basis of the permissible amounts of deposition in the vicinity and by the conditions of distribution given through the location and type of construction of the plant (stack height, adjacent emitters, orographic position, etc.). This should take into account already existing prior load factors and the permissible dust level of the area (this manner of determining the restriction of emission by deposition takes into account the natural laws of the relation between emission, distribution and deposition; Cf. VDI Specifications No. 2289 on Determination of Minimum Stack Height).

3.2 Restriction of Emission on the Basis of Technical Factors:

Unless the conditions in Sec. 3.1 make higher demands on the degree of purity of the flue gases, a technically and economically defensible installation corresponding to type and capacity of the main installation should be provided for the reduction of dust content in flue gas.

In the diagram "Restriction of Dust Emission in Newly Constructed Installations", the maximum permissible dust emission from a new installation is represented as a function of the total amount of ash produced in the furnace installations of the overall installation. For the determination of the amount of ash produced by the overall installation, calculations should be based on maximum continuous output of the steam-generating installation. The permissible volume of dust emission for the new installation results from the percentage indicated in the ordinate as a function of the amount of ash produced in the new installation.

The limit curve of the diagram for maximum permissible dust emission in continuous operation is applicable to normal and technically controllable operating conditions. If special difficulties for the construction of the dust-removal installations result from the type of fuel or conditions of combustion, minor increases of the permissible emission in continuous operation may be authorized after careful examination of all technical possibilities. For an ash total in excess of 100 ton/hr, a special authorization should be procured in each case on maximum permissible emission. A transgression of the established maximum emission values in operation can be accepted only in exceptional cases where subsequent operational factors could not be anticipated during planning and if the dust removal installation was designed according to the most recent technical findings.

3.21 Instructions for Utilization of Diagram:

The regulations on restriction do not indicate the degree of dust separation to be selected but the maximum permissible volume of dust emission (fly-ash including cinders). The decision on the degree of dust separation can be made in each case only in consideration of the dust deposition in the boiler (ash fusion) and the permissible dust emission (it is recommended to include future plans for enlargement in the calculations).

The letter symbols in the diagram and/or the examples below (13) represent:

A_{m_g} (Abscissa) = the total ash from furnace installations of the overall installation in ton/hr at maximum continuous output of the boilers.

A_{m_n} = The total ash from the furnace installation of the new installation in ton/hr under maximum continuous output of the boiler.

(In the determination of the A_m-values, the maximum average 28-day value of the ash content of the fuel to be expected should be used.)

σ_s = (Ordinate) = maximum permissible dust emission from new installation in continuous operation as % of the total ash A_{m_n} of the new installation under maximum continuous output of the boiler.

β = Degree of ash fusion of the furnace installation.

An extrapolation of the limit curve for σ_s to the left or right beyond the range of the diagram should not be made. Special authorisation should be procured for A_{m_g} = over 100 ton/hr. For installations below A_{m_g} = 0.2 ton/hr, VDI Specifications No. 2300 on "Restricting Dust Emission from Boiler Installations, Capacity 10 ton/hr and Less" is applicable.

The air pollution to be anticipated is decisively influenced by the dust emission from the overall installation. The diagram therefore contains as abscissa the total ash A_{m_g} of the overall installation. The overall installation consists of individual aggregates which are structurally related or may be considered as operational units. The overall installation may have one or more stacks.

The ordinate represents the stack discharge σ_s permissible for the new installation as % of the total ash from the new installation.

A new installation is considered to be a newly constructed installation either entirely new or an addition to an existing installation. If a new installation is constructed as an addition to an existing installation, then the existing installation together with the new installation is considered to be the overall installation.

The diagram contains two limit curves for permissible dust emission σ_s. Depending on the rate of ash fusion β of the new installation, either the upper or the lower curve should be used.

The maximum permissible emission indicated in the diagram is valid for maximum continuous load in continuous operation during the authorized operating life of the installation. In connection with this, it should be recalled in particular that the effectiveness of dust separators drops after long-continued operation. In the determination of performance guaranties on the basis of the values for the restriction of emission, this should be taken into consideration accordingly (Cf. Sec. 2.21).

The lines in the diagram traced below an angle of 45° give pointers for the minimum stack height to be employed. Stack height is here considered to be the height of the top of the stack above the ground.

The minimum stack height results from the intersection of the vertical of the respective A_{m_g}-value (abscissa) with the curve for the maximum permissible dust emission. Lesser stack heights require special measures for dust removal. Stack heights lying above the line for the maximum permissible dust emission, i.e., greater stack heights, do not authorize calculation of higher dust emission values than correspond to the curve for the maximum permissible dust emission.

In consideration of the immediate vicinity, however, the top of the stack should be at least 1.7 times as high as the highest building in the vicinity of the stack (11, 12).

Above the 120-m line, i.e., for very large installations, special authorization should be procured for the minimum stack height.

Examples:

a) Existing Installation:

Steam production a_f = 20% (in relation to delivery state)	300 ton/hr
Total fuel	37.0 ton/hr
Total ash in fuel	7.4 ton/hr

b) New Installation:

Steam production a_f = 20% (in relation to delivery state)	200 ton/hr
Total fuel	24.7 ton/hr
Total ash in fuel A_{m_n}	4.94 ton/hr
Degree of ash fusion β = 45%	

c) Overall Installation:

Steam production	500 ton/hr
Total fuel	61.7 ton/hr
Ash total A_{m_g}	12.34 ton/hr

According to the diagram, this then results for the newly constructed part of the installation in A_{m_g} = 12.34 ton/hr according to the limit curve

$$\sigma_s = 3.68\%.$$

The required minimum stack height for A_{m_g} - 12.34 ton/hr (interpolated) amounts to H = 94 m.

This minimum height is sufficient only when a greater stack height is not required by Sec. 3.1 or in consideration of buildings in the vicinity (cf. Sec. 3.21) or on the basis of the VDI Specifications on Sulphur-dioxide Emission.

If unavoidable circumstances permit a stack height of only 85 m, dust emission may then only amount to σ_s = 2.85% (this reduction in stack height is obviously permissible also only if the condition listed in the previous paragraph has been fulfilled). Higher stacks than required by the diagram do not justify higher emission.

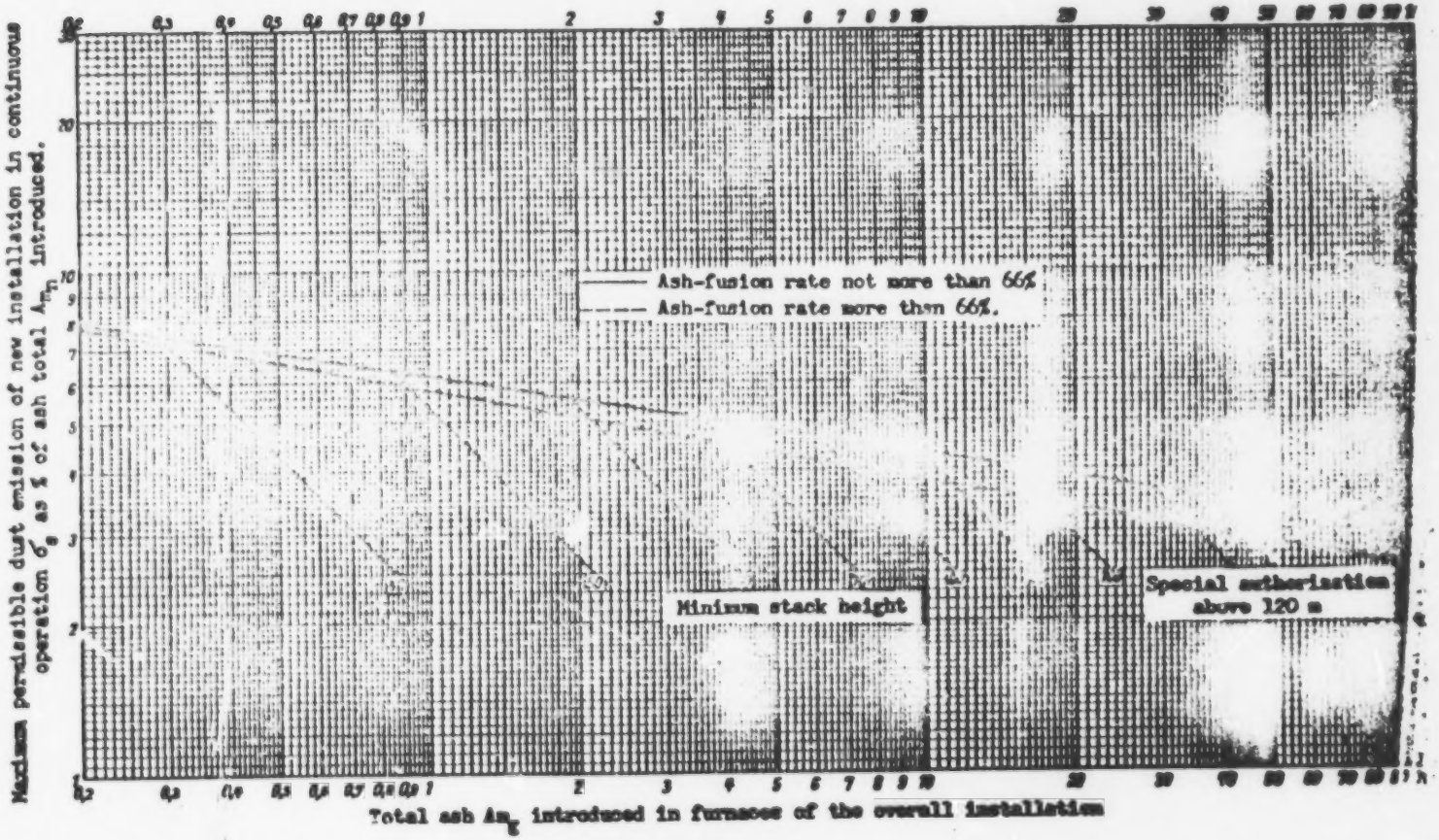
If, for example, the rate of ash fusion β = 70%, the σ_s -value of the lower curve must be used. This then makes σ_s = 3.68% for Am_g = 12.34 ton/hr.

The values for σ_s determined from the above examples shall not be exceeded in continuous operation. The manner in which these emission values are obtained is left to the discretion of the designer of the steam-generating installation. He may make his selection among the possibilities which are offered to him by the design of the steam generator and of the furnace installation (ash fusion) on the one hand and in the selection of the dust separator for flue gases (degree of dust separation) on the other hand.

At a given value of β for the ash-fusion of the furnace, the determination of the necessary continuous degree of dust precipitation for smelter furnaces with 100-% fly-ash recirculation results from the graphic diagram "Ash-Recirculation and Ash-Fusion in Steam Generators" (2.17). For the degree of ash-fusion of β = 45% with a permissible dust emission of σ_s = 4.18%, a continuous degree of dust precipitation of 96.4% is required. For β = 70% ash-fusion and σ_s = 3.68%, a continuous degree of dust precipitation of 91.1% is required.

In view of the drop in efficiency rate of the separator after long-continued operation already mentioned, a correspondingly higher value must be specified for the guaranteed efficiency rate when placing the order.

Restriction of Dust Emission for Newly Designed Installations


Maximum permissible dust emission of new installation in continuous operation σ_g as % of ash total A_{in} introduced.
Ash-fusion rate not more than 66%
Ash-fusion rate more than 66%.
Minimum stack height
Special authorization above 120 m
Total ash Am_g introduced in furnaces of the overall installation

Reproduced from best available copy.

References

1. Air Pollution by Smoke from Boiler Installations. Report on the Status of Technology, Comm. Ass. Steam Boiler Owners, Essen, No. 34/35, 1955, p. 455/566.

2. Schäff, K.: Ash Recirculation and Precipitation in Boiler Installations. Ibid. No. 23, 1953, p. 364/74.

3. Münzinger, F.: Steam Power, 3rd Edition, 1949, p. 22, Springer Berlin.

4. Boiler Operation. Review of Practical Experiences. Issued by Ass. Steam Boiler Owners, 3rd Ed., Essen 1953.

5. Thermodynamic Working Folder. Calculation Data for the Design and Operation of Power Installations. Issued by the Federation of German Power and Heat Engineers, 7th Ed., Düsseldorf, 1953/1954 (Cf. Sheets D-16 and D-18.)

6. Andritzky, M.: Dust Precipitation from Smoke and Boiler Operation. Ibid 1-, No. 23, 1953, pp. 375/84.

7. VDI Specifications No. 2066, Efficiency Tests on Dust Separators, 3rd Ed., Düsseldorf, 1949, New Issue in preparation.

8. Cf. 1, p. 477/84.

9. Diem, M. and R. Trappenberg: Dust Deposition from Smoke Streamers, Ibid. 1-, No. 23, p. 391/95.

10. Drimmel, J., H. Fortak, E. Geisler, B. Hollmann, W. Klug, H. Reuter, H. Stümke and F. Wippermann: Laws on Gas Distribution as Basis for Determination of Minimum Stack Height, VDI Research Publication No. 483 (1961), Cf. further:

    Wippermann, F.: Possibilities of a Theoretical Understanding of the Distribution Process. Dust, Vol. 21, No. 2, pp. 104/09.

    Klug, W.: Practical Utilization of Distribution Calculation Ibid. pp. 109/12.

11. Cf. 1, pp. 504/05.

12. Ibing, R.: Smoke Flow from Stacks in Level Country. VDI Journal, 1954, No. 32, p. 1085.

13. Designation and Significance of the Magnitudes of Refining Furnaces. Ibid, No. 23, pp. 349/350.

14. VGB Specifications for Ordering Dust-Separation Installations for Steam Generators. Ass. Steam Boiler Owners, Essen.

15. Bachmair, A. and K. Schwarz: On the Publication of the First Memoranda of the VDI Committee on Air Purification. Comm. Ass. Steam Boiler Owners, No. 52, 1958, pp. 46/49.

16. Schwarz, K.: On the Regulations on Restriction of the "Emission Specifications" of the VDI Committee on Air Purification. Dust, Vol. 21, 1961, No. 1, p. 6.

17. Cf. 5-, Thermodynamic Working Folder, Sheet D-34.

VDI CLEAN AIR COMMITTEE SPECIFICATIONS, PUBLISHED IN ENGLISH BY THE DIVISION OF AIR POLLUTION, U.S. PUBLIC HEALTH SERVICE

VDI No.	Title
2090	Sources of Air-Polluting Substances
2091	Restricting Dust Emission From Forced-Draft Boiler Installations, Capacity 10 Ton/Hr and Over, Hard-Coal Fired with Mechanical Grates
2092	Restricting Dust Emission From Forced-Draft Boiler Installations, Capacity 30 Ton/Hr and Over, Hard Coal-Dust Fired with Dry Ash Removal
2093	Restricting Dust Emission From Forced-Draft Boiler Installations, Capacity 30-600 Ton/Hr and Over, Hard Coal-Dust Fired with liquid Ash Removal
2094	Dust Prevention - Cement Industry
2095	Dust Emission From Induced-Draft Ore-Sintering Installations
2098	Restricting Dust Emission From Natural-Draft Steam Generators, Capacity 25 Ton/Hr and Less, Lignite-Fired with Stationary or Mechanical Grates
2099	Restricting Dust Emission in Blast-Furnace Operation
2101	Restricting Dust Emission From Copper-Ore Smelters
2102	Restricting Emission of Dust From Copper-Scrap Smelters
2103	The Restriction of Chlorine Gas Emission
2104	Terminology in Air Purification
2106	Permissible Immission Concentrations of Chlorine Gas
2107	Permissible Immission Concentrations of Hydrogen Sulphide
2108	Permissible Immission Concentrations of Sulfur-Dioxide
2109	Restricting Emission of Hydrogen Sulphide and Other Sulphur-Containing Compounds, Except Sulphur Dioxide, From Gas Generators in Coke, Gas, and Coal-Constituent Processing Plants
2110	Restricting Emission of Sulphur Dioxide From Coke Ovens and Gas Plants
2115	Restricting Emission of Dust From Manually Operated Central-Heating Boilers, Capacity 600,000 KCAL/Hr and Less, Fired with Solid Fuels
2281	Restricting the Emission of Fumes From Diesel-Engine Vapors
2284	Restricting Emission of Dust and Sulphur Dioxide in Zinc Smelters
2285	Restricting Dust and Sulphur-Dioxide Emission From Lead Smelters
2290	Restricting Emission From Gas Generators in Coke and Gas Plants
2292	Restriction of Dust Emission in Anthracite-Briquet Factories
2293	Restricting Emission of Dust in Anthracite Processing Installations
2302	Restricting Emission of Dust, Tar Mist and Gas when Charging Coke Ovens
2105	Permissible Concentrations of Nitrous Gases

GPO 869-179